1. A method for recovering high quality steel and non-ferrous metal products from contaminated molten steel scrap containing dissolved carbon and oxygen by in-line continuous processing of the liquid scrap in one or more vacuum desorbers employing physical desorption of impurities into an inert strip gas at typically around 3 mbar total pressure under dispersed contact conditions such as that afforded by melt irrigation of a packed bed within a desorption column/tower with counter current gas flow, using a special procedure for combating the disruptive effects of sub-surface nucleation and growth of CO bubbles, involving recirculation of molten steel product back into the basal region of the vacuum desorbers from liquid metal sumps at atmospheric pressure at a rate many times that of the actual rate of refined steel production and at least in the region of 20 tonnes per minute in conjunction with product metal removal from the liquid sumps, and thereby ensuring operability of the desorbers, continuity of flow of liquid metal as the dispersed phase and the availability of the full diffusional driving forces characteristic of non back-mixed gas/liquid contacting.

2. The method as claimed in Claim 1, wherein the liquid scrap is formed continuously from solid contaminated steel scrap containing up to 1% Zn, up to 0.5% Cu and up to 0.4% Sn and then subsequently refined in a high temperature steelmaking circuit, the overall method comprising the steps of:-

(i) preheating the solid scrap in a protective gas atmosphere to separate out in sequence initially a molten zinc and then a molten aluminium by-product prior to the scrap being assimilated into a forced-circulated stream of molten scrap (liquid scrap) within a closed-loop melt circulation system.

(ii) overflowing, withdrawing or siphoning out continuously the liquid scrap from a melt circulation loop and incorporating it into a gas-lift pumping device which feeds the liquid scrap to the top of the first of two reduced pressure packed towers or similar vacuum desorbers, in which the liquid scrap is raised in temperature from near its liquidus temperature to a very much higher temperature typically in the region 1650 to 1780°C by electrical conductive heating or alternatively radiative heat transfer, whilst ensuring the liquid scrap being preheated behaves as a quiescent melt under a reduced ambient operating pressure, before finally being exposed to the full vacuum of about 3 mbar and then allowing it to irrigate the solid packing and flow downwards by gravity as rivulets or discrete droplets against an upward flow of strip gas typically at pressure of 2-4 mbar, which volatilises elemental copper impurity dissolved in the liquid scrap, but only a relatively smaller amount of dissolved elemental tin, whilst itself becoming almost saturated with iron vapour;

(iii) withdrawing continuously via a barometric leg in the basal region of the desorber the gas-lift recirculated de-copperized liquid scrap containing now less than 0.05% Cu into an atmospheric pressure sump at a rate of at least 20 tonnes per minute and then overflowing it or otherwise transferring it continuously at the refined melt production rate into a second gas-lift pumping system employing a lift-gas to which elemental sulphur or gaseous sulphur or sulphur compound gas has been added to the extent that the liquid scrap absorbs sulphur so that greater than the stoichiometric requirement for all the dissolved tin on average 0.2 – 0.4% Sn to potentially form stannous sulphide is provided;

(iv)   admitting the liquid scrap into the top of a second reduced pressure packed tower or similar vacuum desorber operating at about 3 mbar total pressure and using electrical conductive heating, or alternatively radiative heat transfer , to increase the liquid scrap temperature up to typically 1600 – 1780°C prior to contacting the liquid scrap with an inert strip gas so that stannous sulphide is volatilized from the liquid scrap down to at least 0.01% Sn as it flows by gravity through the tower and then withdrawing continuously via a barometric leg as described previously the now de-tinned and de-copperized liquid scrap into an atmospheric pressure sump, from which the non-ferrous metal depleted liquid scrap is overflown or siphoned continuously for further processing.

3. The method as outlined in Claim 2 with additional features incorporated if the steel scrap charged to the process contains organic coated steel based on PVC or other sources of chlorine contamination, these features comprising contacting pyrolysis gases evolved during scrap preheating with a spray of liquid aluminium droplets followed then by further contacting in a trickle irrigated packed bed employing a fused salt scrubbing medium containing sodium carbonate as the active ingredient in the interests of energy conservation, but more importantly to preclude hazardous dioxin formation.

4. The method as outlined in Claim 2 with the protective gas atmosphere referred to in Claim 2 (i) being preheated at high intensity by the optional inclusion of a molten aluminium droplet contactor based on molten aluminium both as a heat transfer medium and chemical desiccant, utilizing electromagnetic melt circulation together with commercially proven mechanical rotor/splash systems developed for the zinc/lead blast furnace.

5. The method as outlined in Claim 2, wherein the exit desorber strip gas in advance of selective condensation of copper and then tin recovery both as value-added products and which is almost completely saturated with iron vapour, is first subjected to direct contact iron condensation on recirculated liquid steel close to the liquidus temperature, employing residual unmelted steel shells for melt containment, stabilized by generation of high pressure steam for power generation by radiation from the outer surfaces of the retained solid steel shell, which surrounds an irrigated packed bed and its associated gas-lift liquid steel melt circulation system.

used, as discussed more fully elsewhere in the description of this invention. Whether or not this enhancement is really necessary would depend on the particular concentration levels of dissolved carbon and oxygen in the liquid steel at this juncture and is thus subject to a measure of control by the process operator.

The electrical current input to conductively heat the strip of liquid scrap within the desorber is achieved by cooling the exposed external steel sections of the strip 50 and 51 in direct contact with liquid steel at the liquidus temperature well removed from the high temperature region itself but part of the same physical and electrical circuit, fashioned so that the exposed ends can be sealed using conventional vacuum technology practice to afford a means for connection to the AC electrical power supply. A variable low voltage heavy current transformer arrangement will be used for this purpose with possible phase balancing by interconnection of adjacent units to form an overall supply circuit.

It will be appreciated that the concerns about melt freeze-up expressed in the discussion of Figure 6 do not apply with this option. Electrical conductive heating provides the solution to the freeze-up problem. Also it must be stressed that the liquid scrap arriving by the "air-lift" upleg will need to have its inert lift gas bled off before the liquid scrap enters the channel 45 and means for this will have to be provided (not shown in this schematic diagram). The liquid steel progressing to the next step in the continuous process is removed from the lower-level sump 26 by the product siphon 27 as shown in the drawing.

Referring now to Figure 8 of the drawings, this shows a simplified schematic arrangement for preheating clean scrap without organic contamination and without the necessity to recover an intermediate zinc by-product. The preferred inert gas is argon as no pyrolysis gas is formed in the system and the only real concern is water vapour pickup after physical de-watering (not shown) to remove excess liquid water. Scrap 1 is charged through the water seal 52 onto the inclined conveyor 2, which after passage through the water seal 52 discharges its scrap load onto a single horizontal conveyor 3. After initial de-watering (not shown) the scrap passes under a bank of tubular radiant heaters 4 so that its temperature is gradually raised to about 500°C before discharge into the top of the scrap convective heater 10. The principal gas offtake for the closed loop argon recirculation system is at 53, which leads to the high temperature fan or booster for argon recirculation and the closed loop melt circulation system employing molten aluminium both as a heat transfer medium for preheating the argon to about 950°C while comprehensively reducing the water vapour content of the argon before its entry into the base of the convective scrap preheater 10. In this convective scrap preheater the scrap is preheated under benign non-oxidizing conditions without yield loss to about 900°C before admission to the scrap melting arm of the scrap melting melt circulation loop.

A small purge of argon is taken off at 54 to a gas purification system in order to control the build-up of nitrogen in the recirculating argon system. As the protective gas atmosphere extends right through to the melting loop, it is desirable to avoid problems with nitrogen absorption into the liquid steel by tightly controlling its build-up by these means. Nitrogen contamination of the argon arises from air infiltration throughout the system but principally associated with the scrap charged containing inaccessible porosity, which is not displaced by water as the charge material progresses through the water seal. The associated oxygen reacts in the liquid aluminium splash system used for argon preheating and therefore problems with oxygen build-up and steel yield losses due to oxidation do not arise with the system under discussion.